REFLECTOMETER
Soft X-Ray (UHV-) Ten Axis Diffractometer

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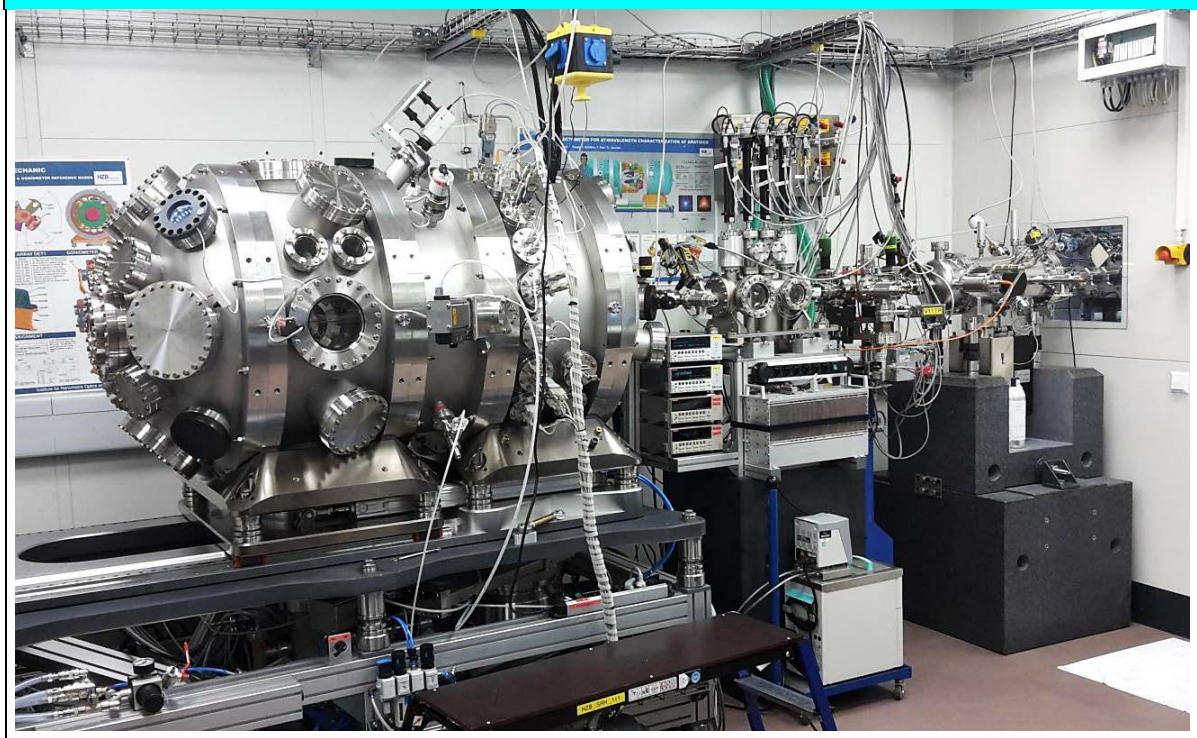


The reflectometer is a multipurpose instrument to determine the optical properties of mirrors, multilayers, gratings, reflection zone plates, films, crystals in reflection or transmission. The experiments can be carried out at a fixed photon energy as function of the angle or as function of energy for a certain angle. The main feature of this Reflectometer is the possibility to incorporate real live-sized gratings or mirrors with a length up to 360 mm and a weight up to 4 kg. The samples are adjustable within six degrees of freedom by a novel UHV-tripod system.

The reflectivity can be measured at all incidence angles for both s- and p-polarization geometry. Azimuthal sample scan is realized by a large goniometer (Huber model 430), while incidence angle and the detector arm are scanned by Huber model 411 goniometers.

The UHV-chamber is evacuated by a 2000 l/s turbomolecular pump. The base pressure is better than $5x10^{-9}$ mbar. A liquid nitrogen cold trap and a Titanium sublimation pump can be activated additionally.

The reflectometer is located in a clean room hutch and coupled permanently to the Optics Beamline at DIP 1.1 operating in the UV and XUV range with the polarization adjustable to either linear or elliptical.

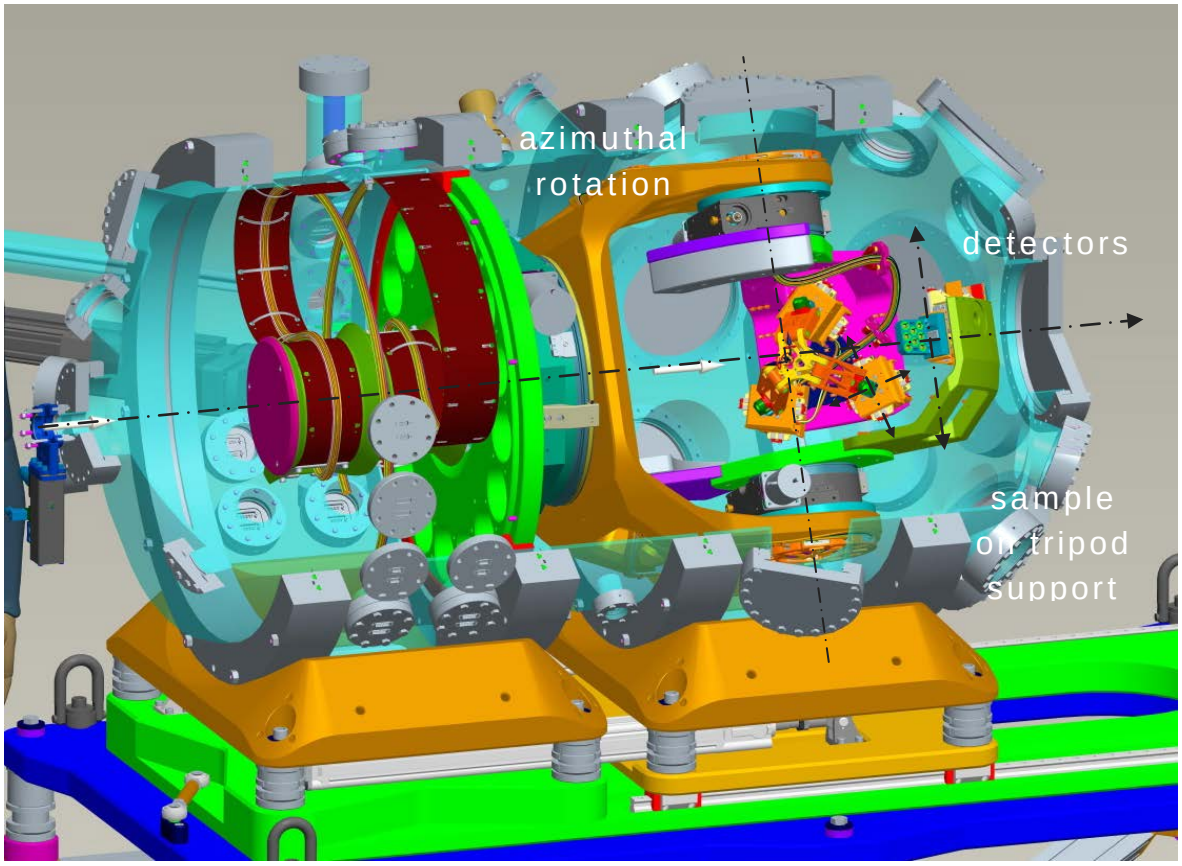
Typical experiments

- **At-Wavelength Metrology on large samples**
- **Reflection grating characaterisation and calibration**
- **Development and performance tests on optical elements:**
- **Mirrors, Multilayers, Zone Plates, Thin films, Crystals**
- **Measurements of reflectivity, efficiency, transmission, diffraction as fct. incidence/azimuthal angle or photon energy**
- **Characterisation of optical surfaces**
- **Scattering (specular - non specular)**
- **Straylight, surface roughness and energy resolution**

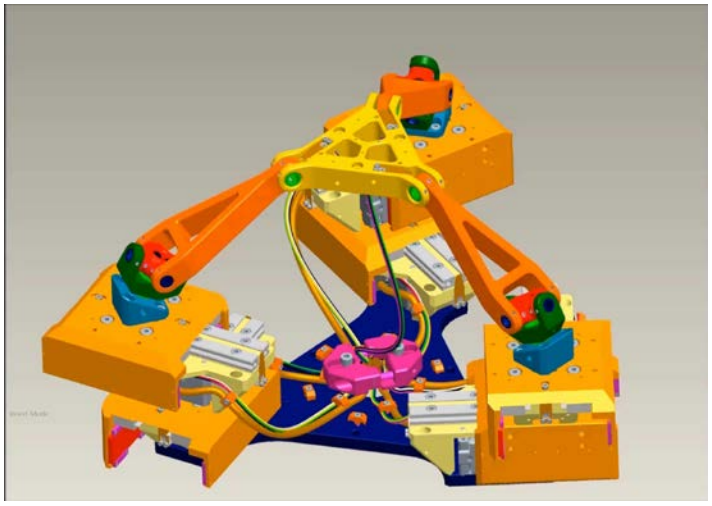
References

1. F. Eggenstein *et al.*, "**A reflectometer for at-wavelength characterization of XUV-reflection gratings**", Proc. of SPIE **Vol. 9206,** 920607, pp. 1 – 12 (2014)
2. F. Eggenstein, *et al.*, "**A reflectometer for at-wavelength characterization of gratings**", Nucl. Instrum. Meth. A710, 166–171 (2013)
3. A. A. Sokolov *et al.*, "**An XUV Optics Beamline at BESSY II**" Proc. of SPIE **Vol. 9206** 92060J, pp. 1 – 13 (2014)

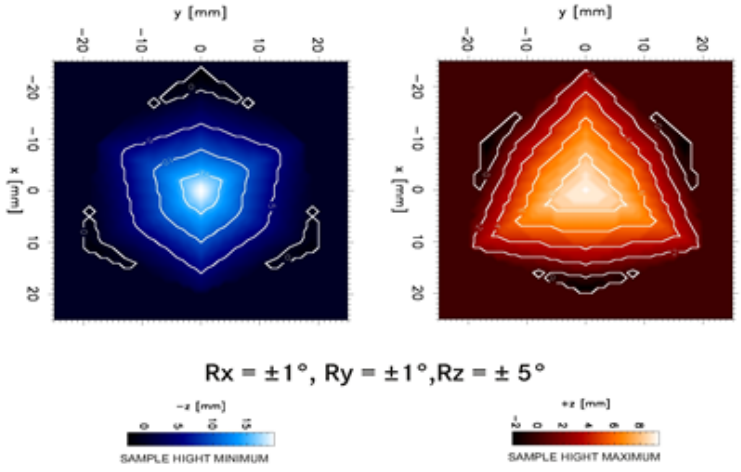
The triple axes configuration



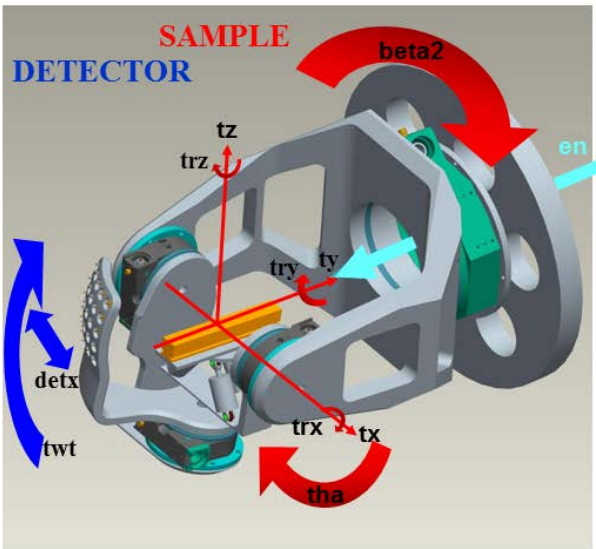
The Tripod stage for six axes sample positioning



TRIPOD SCAN RANGE X,Y,Z

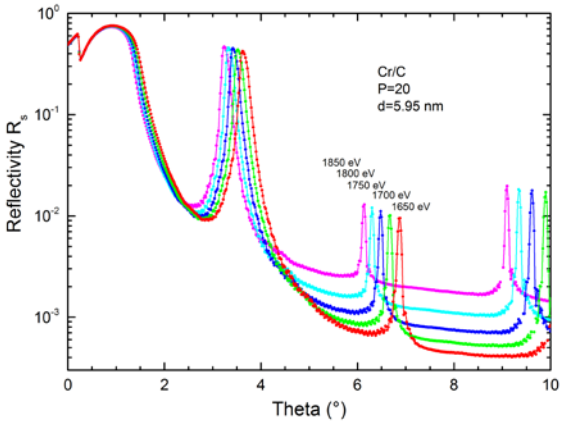


Motors of the 10-axes Reflectometer

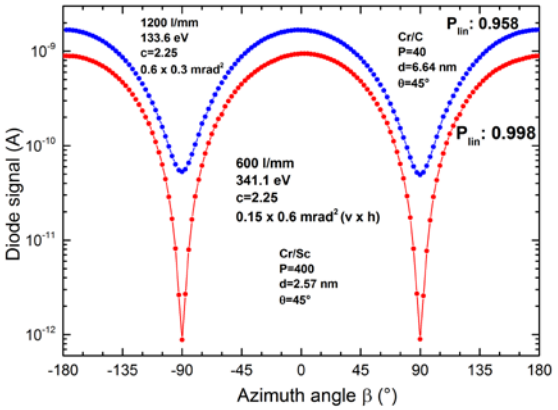


Axis	Name	Max. Range
SAMPLE		
X-trans.	trp1 – ttx	-22 – 22 mm*
Y-trans.	trp2 – tty	-22 – 22 mm*
Z-trans.	trp3 – ttz	-22 – 22 mm*
X-rot.	trp4 – trx	-5° – 5°*
Y-rot.	trp5 – try	-5° - 5°*
Z-rot.	trp6 – trz	-5° - 5°*
Theta	gon3 – tha	-180° – 180°
DETECTOR		* Not simultaneously accessible
Azimuth	gon1 – beta2	-180° - 180°
2theta (in-plane)	gon2 – twt	-180° - 180°
Off-plane	gon4 – detx	-4° - 4°

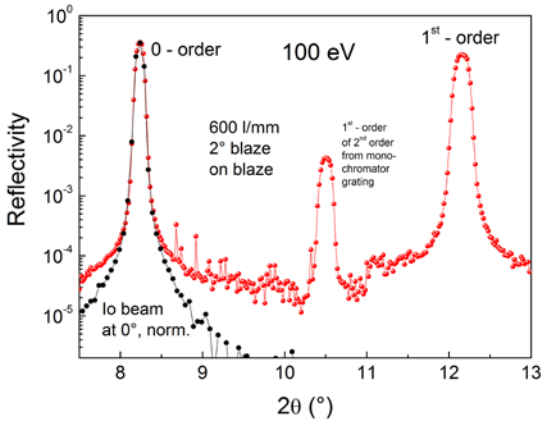
PERFORMANCE/EXAMPLES



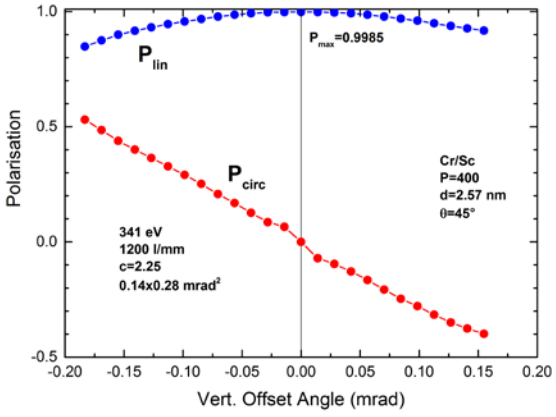
Reflectivity curve of a Cr/C multilayer mirror - (θ:2θ scan)



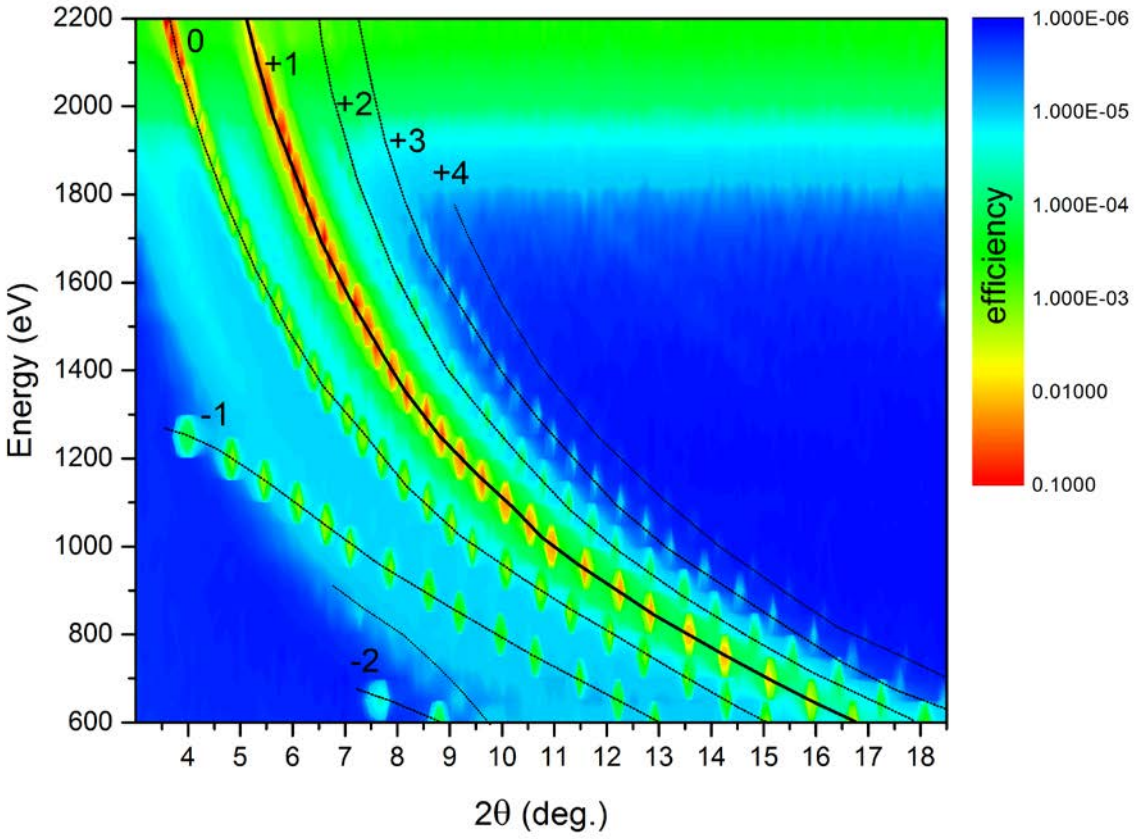
Polarimetry with Cr/C and Cr/Sc multilayer mirrors



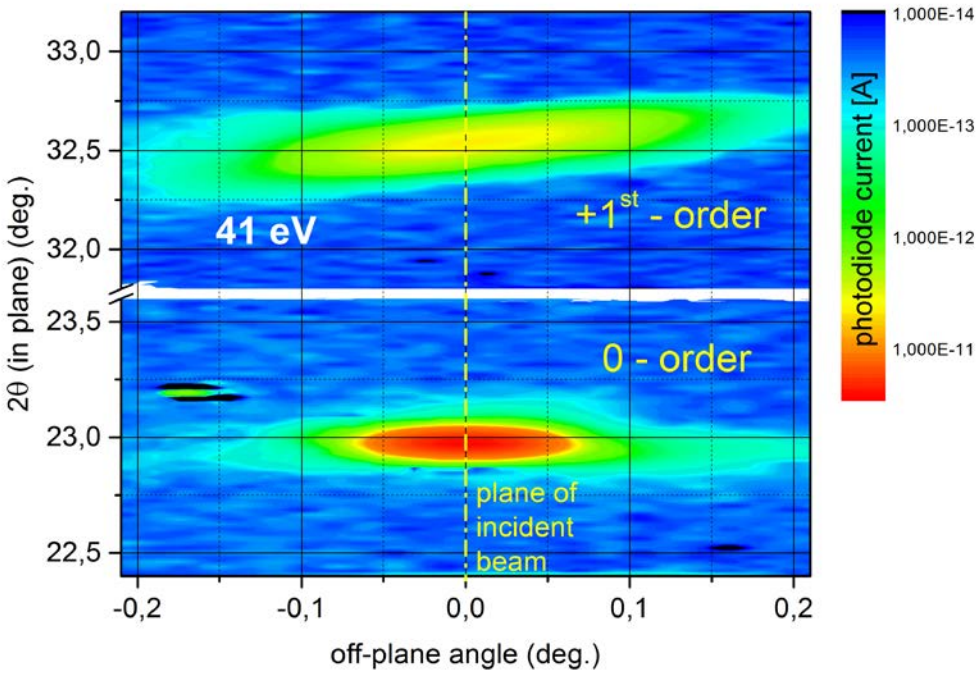
Efficiency of a blazed diffraction grating



Polarisation of incident beam



Efficiency map of a Cr/C multilayer-coated blazed grating (2000 l/mm)



Efficiency map of a reflection zone plate for the tender x-ray range

TECHNICAL DATA	
Samples	**Gratings, Multilayers, Mirrors, Crystals, Thin films**
Maximum sample dimension	360 x 60 x 60 mm^3
Maximum sample weight	4 kg
Minimum optical surface size	5 x 5 mm^2
Incidence angular range (θ)	-180° - 180°
Azimuthal angular range (β)	-180° - 180°
Sample surface scan	15 x 15 mm
Minimum angle to normal incidence	<1°
Minimum step size	0.001°
Sample adjustment	Tx, Ty, Tz, Rx, Ry, Rz
Sample electrical insulation	sample base plate electrically isolated
Load-lock	in preparation (for samples < 50x50x10 mm^3)
Detector	- GaAsP-photodiodes with/without pinhole Keithley electrometer (model 6517) - Channeltron (in preparation) - Kerr detector (in preparation)
Dark current	3 10^{-14} A
Dynamic range	up to 8 orders of magnitude
Entrance aperture/slit	0.16 – 2.5 mm
Scan range in plane (2θ)	-180 – 180°
off-plane (χ)	-4° – 4°
Min. step size in plane	0.0005°
off plane	0.001°
Sample – Detector Distance	310 mm
UHV-chamber	
Vacuum	<5 10^{-9}
Beam height	1420 mm
Adjustments w.r.t. floor	x, y, z, pitch, yaw, roll
Computer control	
Computer server name	reflec.exp.bessy.de
Software	Linux (Debian Etch) / SPEC 5.06
Scan options	hν, θ, 2θ, azimuth, detector off-plane, θ-2θ
multilayers, crystals	Bragg-peak-scan (hν-θ-2θ)
gratings	constant α, -β, -α+β, on-blaze